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Machining Unit

The present invention pertains to a machining unit, especially a welding cell, with the features described in the preamble of the principal claim.

Such machining units, especially welding cells, have been known from practice. They are used for the multistep machining of workpieces, especially of parts or complete bodies of motor vehicles. The unit comprises a plurality of machining stations with robots and has, in addition, at least one turning station, which has at least two work stations for carrying out different operations simultaneously. The turning station is designed in practice as a turntable.

The object of the present invention is to show an improved machining unit.

This object is accomplished by the present invention with the features described in the principal claim.

The replacement of the turntable with two or more multiaxially movable turning units offers various advantages. On the one hand, the reliability of operation and flexibility are increased due to the two independent turning units. The turning units can evade each other thanks to the multiaxial mobility and offer a larger amount of functions and improved adaptability to different tasks than the prior-art

simple turntables. On the other hand, the turning units and the work stations can be uncoupled from one another functionally and in time within certain limits.

The use of transport robots, especially multiaxial articulated arm robots, as a turning unit offers additional advantages. On the one hand, the ergonomics can be improved at work stations served manually, especially at feed sites for feeding and completing workpieces. Due to its degrees of freedom, the robot with its gripper is able to assume an ergonomically optimized position for the feed operations. On the other hand, this flexibility of positioning can also be used to take up different workpieces from a conveyor system. A robot can adapt itself substantially better and above all without structural conversions to changing workpiece pick-up situations. Furthermore, a turning station equipped with robots offers a substantially higher working flexibility because different workpieces can be picked up and transported in a free mix. This can also be achieved by the availability of the turning station, which was mentioned in the introduction. In case of failure of a robot, the other robot or the other robots can still continue working, as a result of which downtime of the unit is avoided.

Robots also have substantial advantages over a turntable at the other work station, which is preferably designed as a joining site, especially a welding site. The transport robot can bring the workpiece being held into a position favorable for machining and also change this position when needed, which is not possible with a turntable. Even though the real costs are higher in case of a robot-supported turning station due to the robots than in case of a turntable, the investment needed to flexibilize the turning station and consequently the entire machining unit is substantially lower than in case of a turntable.

A special advantage of the robot-supported turning station is the markedly increased model flexibilization. In conjunction with bilateral gripper storage units and gripping tools, which are related to the particular models and are kept ready there, the transport robots can simultaneously handle and machine in the unit not only different basic models, but also additional variants within one model, e.g., left and right side wall parts.

Additional advantageous embodiments of the present invention are described in the subclaims.

The present invention is shown in the drawings schematically and as an example. Specifically,

Figure 1 shows a top view of a machining unit with a turning station and two machining stations for a flexible mix of models, and

Figure 2 shows an expanded machining unit with two turning stations and an additional flexibilization for model variants.

Figures 1 and 2 schematically show top views of a machining unit (1), here, e.g.,. a welding cell, for the multistep machining of workpieces (2). The workpieces (2) are parts of vehicle bodies or complete bodies. One or more turning stations (5) and one or more machining stations (15, 16) are arranged one after another along a transfer line (17) within the machining unit (1). The transfer line (17) may extend in a straight line, as in the exemplary embodiment being shown. As an alternative, it may also be bent at an angle. A manual or automatic workpiece feed means (3) is located at the inlet of the unit (1). A likewise manual or automatic workpiece discharge unit (4) is arranged on

the outlet side. At least one worker, who feeds the workpieces (2) manually, introduces them and optionally introduces additional components at the workpiece, is located at the workpiece feed means (3) in the exemplary embodiments shown. The workpiece discharge unit (4) comprises a suitable conveyor (28), e.g., an accumulating conveyor. The workpieces (2) shown are, e.g., front and rear floor panels, doors, engine hoods, etc.

The machining unit (1) is flexible and permits the machining of a plurality of different body models A, B, C in a freely selectable mix. In the unit (1) according to Figure 2, additional model variants, e.g., left and right side parts or doors may also be manufactured in the unit (1) simultaneously or in a free mix. The unit (1) according to Figure 1 may also be expanded correspondingly.

The machining unit (1) comprises at least one turning station (5) and one or more machining stations (15, 16). One turning station (5) and two machining stations (15, 16) are arranged one after another in the transfer direction (17) in the embodiment according to Figure 1. In the variant according to Figure 2, a turning station (5) is arranged on the inlet side, and it is joined in the transfer direction (17) by a machining station (15), which is in turn followed by a second turning station (5) and then by a second machining station (16).

A turning station (5) is preferably arranged at least on the inlet side of the unit (1). The turning station (5) has two or more work stations (6, 7), of which one work station (6) is associated with the workpiece guide means [sic - probably typo for "workpiece feed means" - Tr.Ed.] (3). The other work station (7), which is usually located opposite in the transfer direction (17), is preferably a joining site, especially a welding site, at which the workpiece (2) fed in is machined in a suitable

manner. The second work station (7) is identical to the interface to the next machining station (15) or (16). In the unit (1) according to Figure 2, the first work station (6) with the workpiece pick-up at the second turning station (5) is also the interface with the discharge side of the upstream machining station (15).

The turning stations (5) comprise two or more multiaxially movable, independent turning units (8, 9), which are arranged next to each other and are coordinated with one another in terms of their movements and functions. The turning units (8, 9) can rotate around the vertical axis and are equipped with gripping tools (11, 12, 13), which are preferably replaceable and are adapted to the particular body model or optionally also to the model variant. The turning units (8, 9) may have any desired design. They are preferably rotatable, multiaxial transport robots.

Figure 1 illustrates the working areas (10) of the two transport robots (8, 9), which intersect each other at the work stations (6, 7). As a result, the transport robots (8, 9) can alternatingly approach the work stations with their gripping tools (11, 12, 13) and permit the above-mentioned different operations to be performed with the workpiece mount and the joining machining independently from one another.

The transport robots (8, 9) are designed as stationarily arranged articulated arm robots with preferably six axes in the preferred embodiment. One or more auxiliary axes may optionally be present. In a variant of the embodiment being shown, the transport robots (8, 9) may be positioned movably or unstationarily and perform additional turning or travel movements by means of suitable travel axes. In the exemplary embodiment being shown, the transport robots (8, 9) are preferably arranged on both sides of and mirror symmetrically to the transfer line (17). This arrangement may

also be changed as an alternative. The transport robots (8, 9) are preferably designed as heavy-load robots and have a load carrying capacity of about 500 kg or more. The transport robots (8, 9) are connected with their robot controls to a higher-level unit control and their functions and movements are coordinated with one another via the control (not shown). They move without collision between the work stations (6, 7[)] and preferably on separate paths located on the outside and in opposite directions.

However, the transport robots (8, 9) may be uncoupled from one another to the extent that they do not have to perform all movements and functions with mirror symmetrical synchronization and also not always in the same cycle. This happens especially when a mix of different workpieces (2) with different process times are machined. Process, transport and other ancillary times, e.g., tool change times, can be handled flexibly and optionally changed and adapted for compensation.

Depending on the workpiece flexibility, one or more gripper storage units (14) for different gripping tools (11, 12, 13) may be arranged at the turning station (5) in the working area (10) of the transport robots (8, 9). Three gripper storage units (14) are arranged in a row or in an arc for each transport robot (8, 9) in Figures 1 and 2. The gripper storage units (14) are intended for particular models and model variants and may be provided with suitable conveyors for introducing and removing the gripping tools (11, 12, 13). The gripping tools can thus be replaced or removed and introduced for measuring and maintenance work or for other purposes.

Three different models A, B, C of workpieces (2) are machined in the unit (1) according to Figure 1. The two transport robots (8, 9) have three gripping tools (11, 12, 13) intended for the particular

models for this purpose, and both transport robots (8, 9) have the same set of tools. As is illustrated in Figure 1, the gripping tools (11, 12, 13) are preferably designed as so-called geometry grippers or geo grippers, which grip and hold the workpieces (2) in exactly defined positions.

In addition to the three workpiece models A, B, C, two model variants are processed in the unit (1) according to Figure 2. The transport robots (8, 9) correspondingly have different sets of grippers A, B, C and A1, B1 and C1 as well as corresponding gripper storage units (14).

At the workpiece feed means (3), the transport robots (8, 9) hold the gripping tool (11, 12, 13) being held in a position that is ergonomically favorable for the worker for feeding the workpieces (2) and optionally additional components. This feed position is freely selectable and may, in addition, also be changed within the models according to the model variants, which requires only a reprogramming of the transport robot (8, 9). Likewise, only a reprogramming of the transport robots (8, 9) and the provision of correspondingly changed and adapted gripping tools (11, 12, 13) are required at the turning station (5) even in case of a complete change of the workpieces to completely deferent kinds and optionally also to completely different models and model variants of workpieces.

As an alternative to the manual feed of the workpieces (2) by a worker, the workpieces (2) may also be transferred at the work station (6) to the gripping tools (11, 12, 13) mechanically and automatically. Such a design is shown, for example, in Figure 2 at the second turning station (5) and the work station (6) located there. A robot (20), which has primarily conveying and handling tasks and transfers the workpiece to the waiting transport robots (8, 9) of the second turning station

(5) after the completion of the machining of the workpiece in the machining station (15), is arranged in the upstream machining station (15). This transfer preferably follows directly in the so-called handshake operation. The gripping tools of the robots (8, 9, 20) are designed correspondingly for this purpose. As an alternative, the transfer may also take place by means of an intercalated workpiece storage unit on a table (not shown).

At the work station (7) and the joining site located there, the corresponding transport robot (8, 9) holds the workpiece (2) in the turning stations (5) in a defined machining position. One or more robots (18), e.g., welding robots, which carry out the machining of the workpiece (2), are positioned in the machining station (15, 16). The transport robot (8, 9) can also reorient the workpiece (2) during the machining. Besides welding operations, any other machining operations may be carried out as well. The machining tools of the robots (18) are not shown in the drawings for clarity's sake.

A welding robot (18) and a combined welding and transport robot (19) are arranged in the unit (1) according to Figure 1. After the completion of the joining operation at the work station (7), the robot (19) changes its joining tool to a suitable gripper, takes over the workpiece (2) being kept ready from the corresponding transport robot (8, 9) and transports same to the next machining station (12), depositing same, for example, on a workpiece storage unit (27). The robot (19) then changes the tool again and is ready for the next joining operation.

Two similarly configured robots (18, 19), which are designed as pure machining robots, especially welding robots, as pure transport robots or optionally as a mixed form and are equipped with corresponding, optionally replaceable tools, are arranged at the second machining station (16). The

robots (18, 19) perform, e.g., primarily handling tasks in Figure 1, transporting the workpiece (2) picked up from the workpiece storage unit (27) to one or more stationary machining devices (26) in their working area (10), e.g., to stationary welding tongs, adhesive applicators, etc., and guide them along there. Finally, one or both robots (18, 19) transfer the workpiece (2) to the workpiece storage unit (4), e.g., the conveyor (28) shown.

In the more complex unit 1 according to Figure 2, a transport robot (20), which has one or more, optionally replaceable tools (21) for joining or for handling, is arranged next to the two welding robots (18) in the first machining station (15). A plurality of tool storage units (22) for different tools (21) intended for different models are arranged here, e.g., at the edge of the working area. These are, for example, the tool models A2, B2 and C2.

A plurality of component feeds (23, 24, 25) for different components related to the workpiece models A, B and C are arranged on the other side of the machining station (15). When these components are identical within the model variants, which may be the case, for example, with left and right door components, a number of component feeds (23, 24, 25) corresponding to the number of models is sufficient. If the components also differ within the model variants, the number of component feeds may increase correspondingly. It may also be possible to work with one or more flexible component feeds, which keep ready different model-related or model variant-related components.

After the completion of the machining operation of the welding robots (18) at the work station (7) of the first turning station (5), the transport robot (20) can take over the workpiece (2) from the

corresponding transport robot (8, 9) with the existing gripping tool or optionally with a changed gripping tool and feed it to a stationary machining device (26) and optionally guide it along. After the completion of this operation, it introduces the workpiece (2) to the transport robot (8, 9) standing by in the next turning station (5) and to the gripping tool (11, 12, 13) of the said transport robots in the above-described manner.

The transport robot (20) with its tool (21) can then pick up one or more loose components from the component feeds and add it/them to the deposited workpiece (2) at the second turning station (5).

As an alternative, the transport robot (20) may also perform additional joining and/or handling operations between these transfer operations.

In the second turning station (5) according to Figure 2, a plurality of gripper storage units (14) for corresponding model-related and optionally also variant-related gripping tools (11, 12, 13) are again located at the edge of the working area of the transport robots (8, 9). These [gripping tools] may differ from the set of grippers of the first turning station (5) and are therefore identified by the designations A', B' and C' as well as A3, B3 and C3. As is illustrated in Figure 2, the transport robots (8, 9) also hold different gripping tools A/A1 and A'/A3 in the two turning stations (5). Joining operations are again performed by the two welding robots (18) of the second machining station (16) at the work station (7) of the second turning station (5), and, for example, the components prepared for the operation in the preceding station are joined, e.g., tacked and/or fully welded. An additional transport robot (20), which takes over the workpiece (2) after the completion of the joining operation and transports same to the workpiece discharge unit (4), is likewise

arranged in the second machining station (16).

Various variants of the embodiments being shown are possible. On the one hand, the number and the arrangement of the different stations (5, 15, 16) within the machining unit (1) may vary as desired. Furthermore, the number and the arrangement of the gripper storage units (14) and the gripping tools (11, 12, 13) as well as the necessary or desired variety of models or variants are variable as well.

Furthermore, the design and the outfit of the machining stations (15, 16) may be varied as desired as well. This pertains not only to the number, arrangement and scope of tasks of the robots (18, 19, 20), but to those of other action components as well. The welding robots (18) may, furthermore, also have replaceable machining tools and have corresponding workpiece storage units (not shown) in their working area.

The units (1) shown in Figures 1 and 2 may be built up in the configuration shown immediately at the time of the manufacture. However, as an alternative, they may also be prepared in parts, in which case, e.g., one half of the unit is first built up on one side of the transfer line (17) and the second half is added only later. This minimizes the initial investment and permits the expansion of the machining unit (1) as needed and a purposeful flexibilization when needed. It would also be possible to halve the turning stations (5) at first and have them assume their full function only at the stage of the final expansion.

Furthermore, it is possible to accommodate more than two transport robots (8, 9) in one turning

station (5) and, in addition, to create more than two work stations (6, 7). The transfer line (17) may also branch off. Furthermore, it is possible to build up a plurality of the machining units (1) shown next to one another and to arrange on the inlet side and the outlet side movable workpiece feed means (3) and workpiece discharge units (4), which alternatingly serve the parallel units.

Furthermore, it is possible to approach a plurality of workpiece feed means (3) and workpiece discharge units (4) with the transport robots (8, 9) and the turning stations (5). The number and the arrangement of these [workpiece feed means and workpiece discharge units] depend on the cycle time of the unit (1) and the complexity of the feed and discharge operations.

LIST OF REFERENCE NUMBERS

1	Machining unit, welding cell
2	Workpiece
3	Workpiece feed
4	Workpiece discharge unit
5	Turning station
6	Work station, workpiece pick-up
7	Work station, joining site, welding site
8	Turning unit, transport robot, heavy-load robot
9	Turning unit, transport robot, heavy-load robot
10	Working area
11	Gripping tool, geo gripper, model A
12	Gripping tool, geo gripper, model B
13	Gripping tool, geo gripper, model C
14	Gripper storage unit
15	Machining station
16	Machining station
17	Transfer line
18	Robot, welding robot
19	Robot, welding and transport robot
20	Robot, transport robot

21 Tool for joining or handling

22 Workpiece storage unit

23 Component feed means, model A

24 Component feed means, model B

25 Component feed means, model C

26 Stationary machining device

27 Workpiece storage unit

28 Conveyor